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THESIS

THE EVOLUTION OF MILITARY HEALTH SERVICES SYSTEM WARTIME MANPOWER REQUIREMENTS GENERATION: FROM THE MEDICAL PLANNING MODULE TO THE MEDICAL ANALYSIS TOOL

by

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ABSTRACT ***(maximum 200 words)*** Major changes in post cold war strategy led to changes in force structure, missions, and anticipated casualty rates and challenged the basic assumptions that are fundamental to the process of military medical readiness planning. The Military Health Services System (MHSS) sought to refine its wartime medical requirements in order to identify the medical forces required to support the new strategy. This thesis explores the process used to determine wartime medical manpower requirements within the MHSS, explores the evolution of medical requirements planning models from the Medical Planning Module (MPM) to the Medical Analysis Tool (MAT), and provides a comprehensive analysis of the models. Documents reviewed for this thesis include reports from DoD, GAO and Congress, congressional testimony, studies conducted by think tanks including the Rand Corporation and the Center for Naval Analysis, and pertinent DoD directives and manuals. Additional data were obtained through interviews with key officials involved in the development and implementation of the MAT, particularly the Director for Logistics J-4, Medical Readiness Division, and the primary contractor developing the MAT, Booz-Allen Hamilton. The conclusions of this research are that the MPM is inflexible, inaccurate, incompatible with current technology and planning factors, and not user-friendly. The MAT is more flexible, accurate, compatible with current technology and planning factors, and user friendly than the MPM and is the best alternative for replacing it.

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ABSTRACT

Major changes in post cold war strategy led to changes in force structure, missions, and anticipated casualty rates and challenged the basic assumptions that are fundamental to the process of military medical readiness planning. The Military Health Services System (MHSS) sought to refine its wartime medical requirements in order to identify the medical forces required to support the new strategy. This thesis explores the process used to determine wartime medical manpower requirements within the MHSS, explores the evolution of medical requirements planning models from the Medical Planning Module (MPM) to the Medical Analysis Tool (MAT), and provides a comprehensive analysis of the models. Documents reviewed for this thesis include reports from DoD, GAO and Congress, congressional testimony, studies conducted by think tanks including the Rand Corporation and the Center for Naval Analysis, and pertinent DoD directives and manuals. Additional data were obtained through interviews with key officials involved in the development and implementation of the MAT, particularly the Director for Logistics J-4, Medical Readiness Division, and the primary contractor developing the MAT, Booz-Allen Hamilton. The conclusions of this research are that the MPM is inflexible, inaccurate, incompatible with current technology and planning factors, and not user-friendly. The MAT is more flexible, accurate, compatible with current technology and planning factors, and user friendly than the MPM and is the best alternative for replacing it.

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I. INTRODUCTION

A. BACKGROUND.

The June 1985 Final Report of the Blue Ribbon Panel on Sizing DoD Medical Treatment Facilities recommended that the first priority of medical planning be to refine wartime medical requirements in order to identify the type of peacetime medical force required to support mobilization.[1] Implementation of this recommendation required enhancement of the wartime medical requirements generation model called the Medical Planning Module (MPM).

That same year, Congress directed the Secretary of Defense to produce a plan for revising the organizational structure of the military health care delivery system.[2] This plan would enhance medical readiness by standardizing the methodology used to determine the number of personnel, force structure, and specialty mix necessary to support goals and objectives delineated in DoD's annual defense planning guidance. The House Armed Services Committee specifically endorsed the use and <u>enhancement</u> of the MPM in its Staff Report on Wartime Medical Readiness, December 30, 1985.[3] The Committee also urged that the MPM be expanded to predict physician specialty and nurse and corpsman aggregate and specialty requirements.

Five years later, the end of the cold war presented further challenges to the assumptions that were fundamental to the process of military readiness planning. Major changes in post cold war strategy led to changes in force structure, missions, and anticipated casualty rates.[4] In section 733 of the National Defense Authorization Act for fiscal years 1992 and 1993, Congress directed the DoD to conduct a study of the military medical care system.[5] The DOD was directed to determine the size and composition of the medical system needed to support the armed forces during a war, or lesser conflict, in the post-cold war era. The resulting study by the DoD, referred to as the 733 Study, called for modifications in the MPM that have resulted in the development of replacement models, one of which is the Medical Analysis Tool (MAT).

The discussions and documentation since the mid 1980s that have continuously called for modification of the MPM ignore any other models and may lead us to believe that the DoD has done nothing to improve the MPM since it was initially implemented. However, prior to the MAT, other models had been developed but for various reasons, none made it out of the test phase. The MAT is a derivation of one of these models called Logistics Processor External-Medical (LPX-MED) and is expected to become a medical requirements determinator, providing advantages not available in the MPM or any of the other models since the MPM was developed in the late 1970s.

B. OBJECTIVES.

This thesis will define the process used to determine wartime medical manpower requirements based on DoD planning guidance within the DoD Military Health Services System (MHSS). This thesis will also explore the evolution of medical requirements planning tools from the MPM into the future model--MAT. It will also provide a comprehensive analysis of the MAT. This analysis will address organizational issues, how the MAT relates to the MHSS, and the benefits DoD anticipates once the MAT is implemented. This thesis will be beneficial to planners, component commanders, unit commanders, and operators interested in gaining insight into the support they should expect from the MHSS and how the size and composition of that support is determined.

C. RESEARCH QUESTIONS.

The primary research question is this: what are the implications, for wartime medical manpower requirements planning, of the transition from the MPM to the MAT. Questions that are secondary to this research will involve exploring the nature of the MAT model, its inputs, assumptions, and outputs as well as how the MAT differs from the current model and who is responsible for implementing and operating the new model.

D. SCOPE.

This thesis will include an examination of the process used to determine wartime medical manpower requirements based on DoD planning guidance within the DoD MHSS. This thesis will also explore the evolution of medical requirements planning tools from the MPM into the future model--MAT. It will also provide a comprehensive assessment of the MAT, its organizational issues, how the MAT relates to the MHSS, and the benefits DoD anticipates once the MAT is implemented.

E. LIMITATIONS.

Some extraneous factors have placed limitations on the research of this topic. The first major constraint is that the MAT is still under civilian contract and is not fully developed. This has limited the amount and type of documentation and information that is available for review. Much of the analysis conducted by this thesis on the MAT is based on information that is a result of interviews conducted with key DoD officials responsible for the MAT's development and implementation and representatives of the primary contractor developing the MAT. Only 'beta' versions of the MAT were available for hands on evaluation. Any conclusions as to the MAT's strengths, weaknesses, or capabilities may be subject to change once the MAT has been completed and released for use.

The second major constraint that has placed limitations on this research is that the MPM operated within the World Wide Military Command and Control System(WWMCCS) environment. This system no longer exists, having been replaced by Global Command and Control System (GCCS). This has prevented any hands on evaluation of the MPM and has limited the evaluation of the MPM to the available documentation, archived information, and interviews with officials that were previously responsible for design, development, and implementation of the MPM.

A specific explanation of how these constraints affected the research will be provided later in this thesis as the topics are addressed.

F. ASSUMPTIONS.

For the purposes of this thesis I will only make two assumptions. First, that the reader understands that the requirements determined from the model output are subject to additional analysis that may consider factors, e.g., politics, resources, or limitations, that are not incorporated into the model. Second, that the reader understands that the analysis in this thesis is only concerned with how medical requirements determination occurs in relation to the models and the output of those models.

G. METHODOLOGY.

Archival research methods were utilized to gather data for this thesis. Documents that were reviewed include, but are not limited to, DoD reports, including Inspector General reports, GAO reports, congressional reports, congressional testimony, studies conducted by outside 'think tanks' such as Rand Corporation and the Center for Naval Analysis, and any pertinent DoD directives or manuals. Because documentation on the MAT was limited, additional data was obtained through interviews with key DoD officials involved in its development and implementation. The primary sources for this data were the Joint Chiefs of Staff, Director for Logistics J-4, Medical Readiness Division, the primary contractor developing the MAT, Booz-Allen Hamilton, the Office of the Assistant Secretary of Defense for Health Affairs, and Chief of Naval Operations, Medical Resources Plans and Policy, N-931. A comprehensive compilation of this data provided the basis for the information required to answer the research questions posed in this thesis.

H. DEFINITIONS AND ABBREVIATIONS.

A glossary of acronyms and abbreviations used in this thesis is included as Appendix A.

I. ORGANIZATION.

This section provides a brief description of how the remaining thesis chapters fit together and what is addressed in each.

Chapter II presents a discussion of the medical requirements planning process and provides definitions and explanations of key concepts in understanding the process, critical factors and policies, and the medical requirements generation process.

Chapter III will discuss medical requirements planning models: the types of models, factors in choosing a model type, and the criteria for evaluating the models. This chapter will also provide an overview of the organizational issues surrounding replacement model development and implementation.

Chapters IV and V will provide an evaluation of the MPM and the MAT, respectively, based on the criteria established in chapter III. They will include discussion of the nature of each model, major assumptions, inputs and outputs, and the strengths and weaknesses of each model.

Chapter VI will conclude this thesis with a summary, conclusions, and recommendations for future study.

II. THE WARTIME MEDICAL REQUIREMENTS PLANNING PROCESS

A. THE MEDICAL READINESS MISSION.

The purpose of this chapter is to explore and define the process by which the MHSS determines what is required to meet its mission. The readiness mission of the MHSS encompasses the ability to mobilize and sustain field medical services and support for any operation requiring military services and to project and maintain the continuum of health care resources required to provide for the health of the force during a time of war or lessor conflict.[6] The concept of medical readiness is to plan and program for the requirements of, and be ready to execute, the wartime mission.

The starting point of an assessment of wartime requirements is the Defense Planning Guidance (DPG), which serves as the basis for all planning and programming activities within the DoD.[7] The DPG establishes the potential combat operations by issuing 'scenarios' which form the analytical basis for determining planning and programming requirements. These scenarios are used to generate the critical planning factors, i.e., casualty estimates and evacuation streams, which lead to determination of wartime requirements within the context of medical requirements planning. Understanding these critical planning factors, and the context in which they are applied, is crucial to choosing the type of model, and evaluating the models used to translate those critical planning factors into a requirement.

B. THE MEDICAL REQUIREMENTS PLANNING CONTEXT.

Medical requirements are planned within two contexts--echelons of care and operation zones (OPZONEs). As stated in the previous section, the wartime mission of the MHSS is to project and maintain the 'continuum' of health care resources required. The concept of a continuum implies that a casualty will be moved seamlessly from the point of injury through the phases of the health care system until that casualty reaches the level of care required to return them to duty.

The effectiveness of this system is measured in its ability to save life and limb, reduce the disease or nonbattle injury (DNBI) rate, and return patients to duty quickly and as far forward in the theater as possible.[8] The continuum of care concept is illustrated in Figure 1, Mobility and Capability in the Navy's Medical Care System, which shows the Navy's plan for moving casualties from the point of injury, across increasing echelons of care, to a facility in the continental United States (CONUS) if necessary.

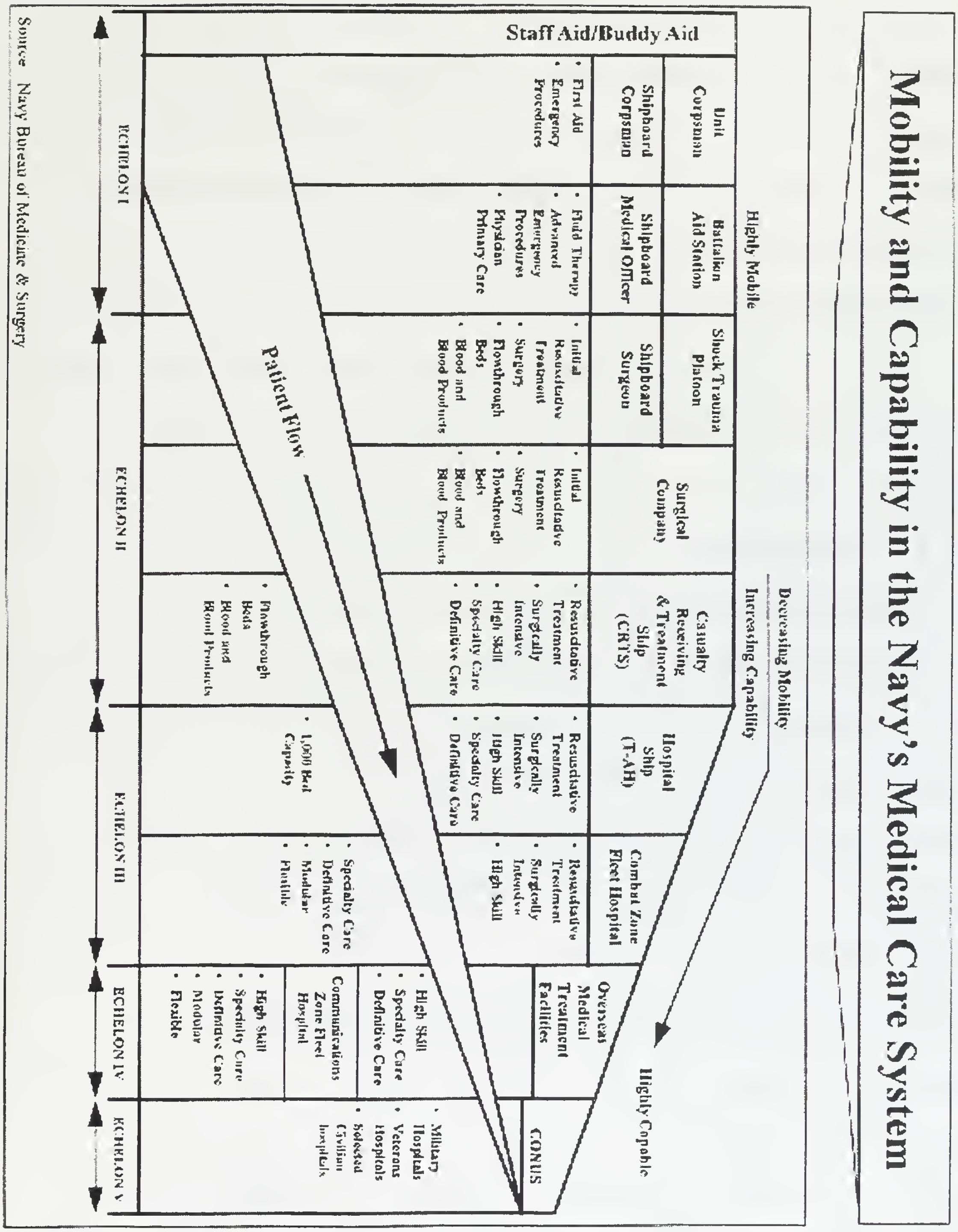

Mobility and Capability in the Navy's Medical Care System
Staff Aid/Buddy Aid
Highly Mobile
Decreasing Mobility
Increasing Capability
Highly Capable
Unit Corpsman
Shipboard Corpsman
• First Aid
• Emergency Procedures
Battalion Aid Station
Shipboard Medical Officer
• Fluid Therapy
• Advanced Emergency Procedures
• Physician Primary Care
Shock Trauma Platoon
Shipboard Surgeon
• Initial Resuscitative Treatment
• Surgery
• Flowthrough Beds
• Blood and Blood Products
Surgical Company
• Initial Resuscitative Treatment
• Surgery
• Flowthrough Beds
• Blood and Blood Products
Casualty Receiving & Treatment Ship (CRTS)
• Resuscitative Treatment
• Surgically Intensive
• High Skill
• Specialty Care
• Definitive Care
• Flowthrough Beds
• Blood and Blood Products
Hospital Ship (T-AH)
• Resuscitative Treatment
• Surgically Intensive
• High Skill
• Specialty Care
• Definitive Care
• 1,000 Bed Capacity
Combat Zone Fleet Hospital
• Resuscitative Treatment
• Surgically Intensive
• High Skill
• Specialty Care
• Definitive Care
• Modular
• Flexible
Overseas Medical Treatment Facilities
• High Skill
• Specialty Care
• Definitive Care
Communications Zone Fleet Hospital
• High Skill
• Specialty Care
• Definitive Care
• Modular
• Flexible
CONUS
• Military Hospitals
• Veterans Hospitals
• Selected Civilian Hospitals
Patient Flow
ECHELON I
ECHELON II
ECHELON III
ECHELON IV
ECHELON V
Source: Navy Bureau of Medicine & Surgery

Figure 1.

The MHSS system is made up of five echelons of care, extending back from the point of wounding, injury, or illness. Each succeeding echelon possesses the same treatment capabilities as those echelons forward and adds new capabilities.[8]

1. Echelon I.

Care is rendered at the unit level and includes self and buddy aid, examination, and emergency lifesaving measures.

2. Echelon II.

Care is rendered at a MHSS organization by a team of physicians or physician assistants, supported by appropriate medical, technical, or nursing staff. At this level, care includes basic resuscitation and stabilization and may include surgical capability, basic laboratory, limited x-ray, pharmacy, and temporary holding facilities.

3. Echelon III.

Care administered at this level requires clinical capability normally found in a medical treatment facility (MTF) that is typically located in a lower level enemy threat environment. The MTF is staffed and equipped to provide resuscitation, initial wound surgery, post operative treatment, and care that may include the first steps toward restoration of functional health.

4. Echelon IV.

This echelon of care will provide not only a surgical capability but also further definitive therapy for patients in the recovery phase.

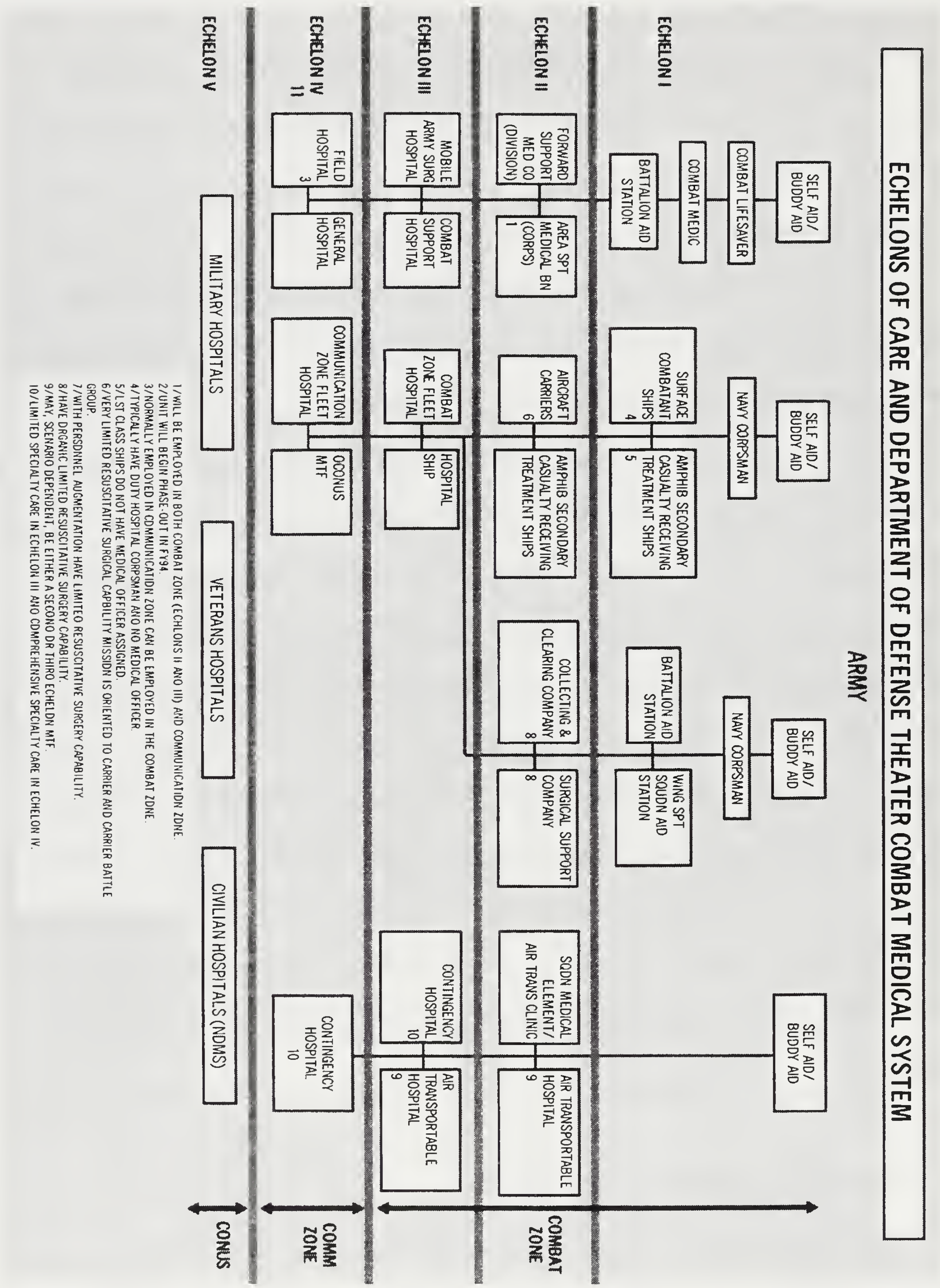
5. Echelon V.

Care is convalescent, restorative, and rehabilitative and is normally provided by military, Department of Veterans Affairs, or civilian hospitals in CONUS.[9]

The capabilities associated with the echelons of care are spread across three zones: the combat zone, the communication zone, and CONUS. The combat zone is that area required by combat forces for the conduct of operations. The communication zone is the rear part of the theater of operations which contains the lines of communication, establishments for supply and evacuation, and other agencies required for immediate support and maintenance of the field forces.[10] Figure 2 illustrates how each service provides the required capabilities, within each echelon and across each zone, as well as the types of units that will provide them.

C. CRITICAL PLANNING FACTORS.

As stated earlier in this chapter, the scenarios established by the DPG are used to generate the planning factors critical to determining wartime medical



source: Joint Pub 4-02

Figure 2.

requirements. These factors are casualty estimates and evacuation streams, and are made up of a number of components which, depending on how they are derived, have considerable effect on the final output. What follows is a discussion of each critical factor, their components, as well as an explanation of how they affect the requirements generation process.

1. Casualty Estimates.

Casualty estimates are calculated by multiplying the total population at risk (PAR) by the casualty rate for that population. PAR represents the population of each service, calculated using the Time Phased Force Deployment Data (TPFDD), assumed to be at risk of being wounded in battle, contracting a disease, or facing a nonbattle injury. Casualty rates vary by combat intensity, type of casualty, and type of unit (combat versus support).[8]

Casualty rates are determined external to the MHSS and are provided to the MHSS for planning purposes. The final casualty estimate is made up of two medical casualty types; wounded in action and DNBI, and four non-medical casualty types; prisoner of war (POW), missing in action (MIA), killed in action (KIA), and administrative loss. Medical casualties, as the term implies, are used to estimate medical requirements. The total number of medical casualties is further refined into the type of capability required to treat each casualty. These required capabilities are in turn translated into the medical requirement for personnel, beds, and evacuation assets, e.g., surgical casualties will require a surgical capability which translates into surgical staffs and equipment, surgical beds, and evacuation to a surgical unit.

2. Evacuation Streams.

Evacuation streams are a function of the number of casualties, as calculated above, and movement of those casualties from the point of injury through the phases of the health care system until those casualties reach the level of care required to return them to duty. The movement of casualties relies upon two factors: the evacuation policy and the evacuation delay.[8]

The evacuation policy states, in the number of days, the maximum period of noneffectiveness (convalescence or hospitalization) that casualties may be held in the theater (combat zone and communication zone) for treatment. The policy does not imply that a casualty must be held in the theater the entire period for treatment. Casualties that are not expected to return to duty (RTD) within the number of days expressed in the theater evacuation policy are evacuated as soon as their medical condition permits. This policy is flexible and changes as the tactical situation shifts. This ensures that nonfixed MTFs retain mobility and the capability to accommodate anticipated surges in patients. Shorter evacuation policies within theater reduce theater bed requirements but increase requirements for beds elsewhere and evacuation requirements, e.g., helicopters, airplanes, air crews, airfields, and support. Figures 3 and 4 graphically represent the relationship between evacuation policy and requirements in theater.

The second factor in determining evacuation streams is evacuation delay. Evacuation delay occurs when casualties that are ready for evacuation must remain at their current echelon of care due to lack of evacuation assets or other constraints, e.g., weather or the tactical situation. Evacuation delay will slow the movement of casualties rearward and increase the requirement for beds in the theater.[8]

D. THE MEDICAL REQUIREMENTS GENERATION PROCESS.

The casualty estimate constitutes the expected workload that a network of medical assets must be prepared to deal with for a given scenario. The casualty streams constitute the assumptions of how a network of medical assets intends to handle the workload it faces in a given scenario.

Separately, workload and assumptions don't reveal very much about the total medical requirement, but when combined,

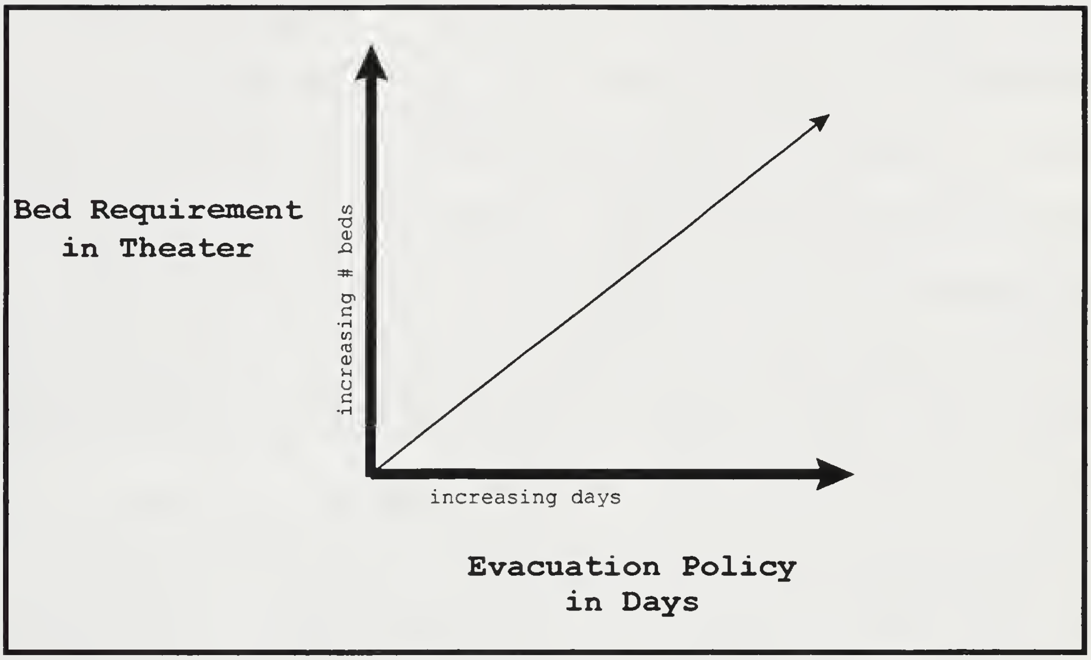


Figure 3.

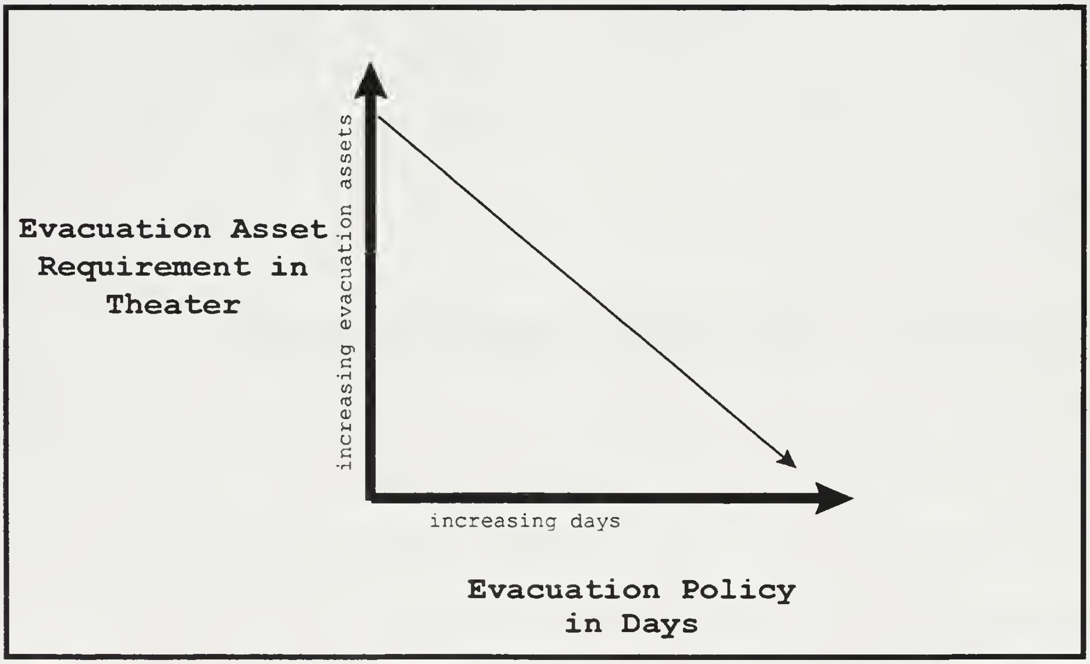


Figure 4.

the workload and assumptions for a single scenario will clearly define the medical requirements for that scenario.

This is where a model comes in. It is the model that translates the workload and assumptions for a given scenario into a requirement for that scenario. Figure 5 is a graphical illustration of how the medical requirements generation process works.

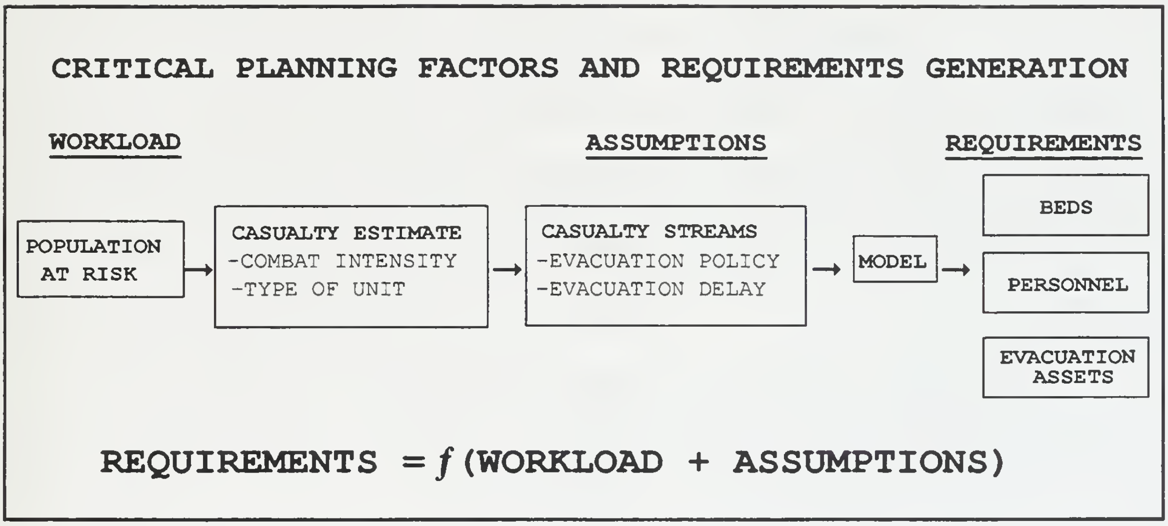


Figure 5.

The 'model' is the function that is designed to take the inputs, workload and assumptions, and produce an output, the requirement. The next chapter will discuss medical requirements planning models: the types of models, factors in choosing a model type, and the criteria for evaluating the models.

III. MEDICAL REQUIREMENTS PLANNING MODELS

A. MODELING DEFINED.

"Modeling", in its most simplistic form, is something that man does every time he makes a rational decision. The process of modeling entails using qualitative and/or quantitative information, within a framework representing reality, to predict the outputs or outcomes of a certain course of action within that reality. The process of rational thought then evaluates the predicted outputs and outcomes against criteria and chooses between given courses of action or generates a new course of action that meets that set of criteria.

The concept of modeling simply recognizes that the potential negative consequences of some decisions are so great that, in order to minimize these consequences, an attempt is made to build a representation of that decision (mathematically or graphically) to predict the possible outcomes and assess the risks involved. In a military context, the processes that models represent sometimes are not fully explorable short of war or economically unacceptable experiments. In these circumstances, models may be used to provide a somewhat rational means for dealing with the overwhelming complexities and unknowns of the future.[11] Models can be employed to investigate "what if" questions, to explore the possible consequences of a wide variety of courses of action, and to determine system outputs given constraints and inputs.

Models never perform analysis. Analysts do analysis, aided by models where appropriate. The model may be used to provide insight or it may be used to predict. Models of combat vary, from realistic field exercises and maneuvers on one extreme, to abstract mathematical relationships involved in predicting theater level medical requirements for a major regional conflict on the other.

This chapter is a discussion of medical requirements planning models: the types of models, factors in choosing a model type, and the criteria for evaluating the models.

B. TYPES OF MEDICAL REQUIREMENTS PLANNING MODELS.

Medical requirements planning models differ in design and purpose. The most important difference among them is concerned with the type of output that the model produces, whether they ***calculate*** a requirement (calculator models) or ***simulate*** what is likely to happen given some set of requirements (simulation models).[12]

1. Calculator Models.

Calculator models produce requirements from a given set of mathematical relationships. For example, for a given PAR and a given casualty rate for that PAR, simple multiplication leads to the expected number of casualties. With a few more assumptions as to casualty type, evacuation policy, and evacuation delay, the model will calculate the number of beds required in theater.[12]

Calculator models produce values that are determined without repeated sampling of statistical distributions and without multiple passes through a time sequence. These models might employ functional (algebraic) relationships, logical relationships, empirical constants, e.g., work standards and protocols, heuristic decision rules, or a combination of the above that satisfy the model objectives.[11]

2. Simulation Models.

Medical requirements simulation models require the user to first design a network of medical facilities and populate each facility with medical resources such as beds and medical personnel. Given certain variables whose values depend on an assumed probabilistic outcome, the model evaluates how well the resources present in the network perform at treating and evacuating casualties. This type of model is also referred to as a "course of action" analyzer and is designed to identify inefficiencies within the network, allowing the planner to manipulate the type and number of assets used to build the most efficient network for a given scenario.[12] The inefficiencies can be either overuse or underuse of assets.

These models are evaluative, in that they are used to discover and examine the impacts of various decision policies rather than to determine an appropriate decision. From an analysis of the results of a simulation model, an analyst can modify policies embedded in the model and reassess the impacts. This iterative procedure will eventually lead to an understanding of the response of the system to a variety of alternative policies and will further indicate where procedures, resources, and other factors can be modified to enhance the system's efficiency.[11]

C. CHOOSING A MODEL TYPE.

Choosing a model type relies on two factors: the characteristics of the problem to be solved and the amount, quality, and availability of the necessary data.

The characteristics of the problem to be solved, or the objective of the model, is the first and foremost driving factor in selecting a model type. The characteristics of the problem include the type of decision to be made and types of information needed to make that decision.

If the type of decision to be made is to determine the type and quantity of medical assets required to meet the mission under a given scenario, then the model type most appropriate is a calculator model. On the other hand if the type of decision to be made is how to optimize the efficient use of a given force within a scenario, then the model type most appropriate is a simulation model. If the problem to be solved is both to determine type and amount of medical assets required as well as the optimal efficient use of those assets for a given scenario, then the most appropriate type of model would be a combination of both a calculator and a simulator model.

Although less important than the characteristics of the problem to be solved, the amount and quality of available data is always a driving factor in determining the type of model that would be the most feasible and efficient for any application.[11] Results from models which rely heavily on proxies for data which do not exist may be very inaccurate, and conversely, models which incorporate approximations when actual data are available may miss important sensitivities. Therefore, the selection of the type of modeling approach to reach the solution of a problem must be compatible with the characteristic of the problem and the data available.

D. EVALUATING THE MODELS.

A model, then, is a substitute for reality when that reality is too dangerous, too expensive, or just not possible. To evaluate a model is to determine if the model is an adequate substitute for reality to solve the problem or meet the objective.[13] It is important to note that what is being evaluated here is not the output of the model but the model itself, its design, its assumptions, its reasonableness, as well as its representation of reality. Validation of the model, within a certain level of confidence, denotes a valid output of the model within the same level of confidence.[11] In addition to being valid, the model must also be relevant, meaning that it has significant and demonstrable bearing on the matter being modeled.

The most important part of any evaluation is setting the criteria against which the models will be evaluated. Accuracy, compatibility, and usability are the criteria used in this thesis to evaluate the MPM and the MAT models. The criteria are made up of numerous factors which are either direct measurements or proxies used to measure the validity and relevance of the model.

1. Accuracy.

Accuracy is measured by three factors: flexibility of the model, the degree of measurement of its inputs and assumptions, and the reasonableness of its mathematical relationships.

Flexibility of the model is concerned with the design of the model so that it will allow the most accurate representation of reality within the context of the model. For example, a model which is designed to represent an event that occurs at different rates within one area, but only allows for measurement at a single rate per area, would more accurately represent reality by increasing the flexibility of the model and allowing for numerous, or even unlimited, rates within one area.

In the case of evaluating the MPM and the MAT, flexibility will be measured by number of OPZONEs, number of separate PARs per OPZONE, and whether or not they allow for a dispersion factor. The dispersion factor is used to account for two factors: 1) that all the beds needed won't be in the right place at the right time, and, 2) that medical facilities will be required to shut down their capability and move from time to time to adjust to the tactical situation.

Degrees of measurement of the model are concerned with whether the model matches reality in regards to the increments of measurement. For example, a model which is designed to represent an event that is time critical, but only allows for measurement in days, would more accurately represent reality by increasing the degrees of measurement to hours, minutes, or even seconds. In the case of evaluating the MPM and the MAT, degrees of measurement will be measured in the increments used to measure length of stay and evacuation delay.

The reasonableness of the mathematical relationships is concerned with whether the model's algorithms, used for converting inputs and assumptions into outputs, accurately represents reality. In the case of evaluating the MPM and the MAT, studies have already concluded that the algorithms used by the MPM and those used by the MAT, which are derivations of those used in the MPM, are reasonable.[14] While this alone does not let us conclude that the model is valid or relevant, it is an important part of determining its validity and relevance.

2. Compatibility.

Compatibility of the model is measured by two factors: compatibility with current technology and compatibility with current planning factors.

Compatibility of the model with current technology is concerned with whether the model can be employed effectively within the current technological environment in the context of the problem to be solved or the objective of the model. In the case of the MPM and the MAT, compatibility with current technology will be measured by their compatibility with GCCS and the type of computer platform required to operate them.

Compatibility of the model with current planning factors is concerned with whether the model can be employed effectively within the current planning environment in the context of the problem to be solved or the objective of the model. In the case of the MPM and the MAT, compatibility with current planning factors will be measured by their compatibility with current DPG, current casualty rates, and current treatment protocols.

In a sense, this is another measure of flexibility, in that, if the current planning factors change over time, which is more likely than not to happen, the model must be flexible enough to change as well. If the model is not flexible enough to allow for changes, then, at an absolute minimum, it must be compatible with the current planning factors, acknowledging that the model will become obsolete when they change.

3. Usability.

Usability is measured by three factors: the training required, user-friendliness, and speed.

The training required to use the model is concerned with whether or not the complexity of the model will require long periods of intricate training which may prove to be too costly and may undermine the objective of the model.

The user-friendliness of the model is an evaluation of how the model is presented to the ultimate user and whether or not the model is easily used or too hard to use and abandoned for simpler methods.

The speed of the model is simply a comparison of the amount of time that is required to use the model to reach a desired outcome. For this evaluation, if the models were equal on all other factors, the faster model would be considered more effective.

The next two chapters will contain brief discussions of each model, an evaluation of each model using the criteria discussed above, and a summary of each model's strengths and weaknesses.

IV. MEDICAL PLANNING MODULE

A. MEDICAL PLANNING MODULE.

The following evaluation of the MPM is based on review of users manuals and archived printed reports generated by the MPM. As noted in chapter one, the MPM operated within the World Wide Military Command and Control System (WWMCCS) environment. Because this system no longer exists, having been replaced by the Global Command and Control System (GCCS), for this evaluation the actual hands-on use of the MPM was not possible.

The MPM was developed in the late 1970s in response to the Joint Planning Community's need for a consistent means of predicting and evaluating medical requirements in support of Operation Plan (OPLAN) development. The MPM was intended to be compatible with the organization and unit structure of each of the services and to recognize the unique requirements of each service.

The MPM was designed to assist the medical planner in quantifying the impact of a proposed OPLAN on the medical system through the automated interface of the TPFDD file, the Medical database (MDB), and a Medical Working File (MWF) containing OPLAN-dependent planning factors provided by the medical planner. The MPM is composed of a series of software modules that are responsible for receiving and storing user input data generated through use of the MPM input options.

The MPM operates in the Joint Operation Planning and Execution System (JOPES) and can be accessed by any user at the user's WWMCCS station. The MPM functions in both an online interactive mode and an offline batch processing mode. In the online mode, the planner interfaces with the MPM software and attendant files, while connected through their WWMCCS terminal, to generate a new or modify an existing MWF. When the planner completes the manipulation of the MWF, the file is saved to tape or disk. The user then asks the MPM to perform up to four offline batch jobs that interface planner input data with the JOPES MDB, perform all computations, and print the appropriate set of reports.

As the calculations are performed, data is taken from the MWF and MDB repeatedly until all user-requested output reports are formulated. The MPM reads the planner generated PAR and medical planning factors (MPF) records from tape, extracts related data from the MDB, and creates OPLAN-unique data tables to serve as input to a series of algorithms that generates admissions, flows patients through the medical system, and computes medical requirements. All calculations are performed in the offline batch mode rather than in real-time online mode, which means that the user cannot view output reports on the computer screen, but must wait for the hard copy printed reports.

Below is an evaluation of the MPM using the accuracy, compatibility, and usability criteria set out in chapter three. Following the evaluation is a summary of the MPM's strengths and weaknesses discovered in this evaluation.

B. EVALUATION OF THE MODEL.

1. Accuracy.

As stated in the previous chapter, for this evaluation accuracy will be measured by three factors: flexibility of the model, the degree of measurement of its inputs and assumptions, and the reasonableness of its mathematical relationships. The evaluation below discusses each of these factors, with the exception of the reasonableness of its mathematical relationships, which was already discussed in the previous chapter.

The process of measuring accuracy involves evaluating how well the model represents reality. In this case, the reality that the MPM must represent is what the future battlefield will look like, how our forces will be employed in that battlefield, and how the MHSS will support those forces. Such concepts as dominant maneuver, precision engagement, and focused logistics indicate that the future battlefield will be made up of multiple areas of conflict with the battles being waged by smaller, highly mobile, multi-disciplined, task organized units.[15] This is the context for measuring accuracy.

The MPM is only flexible enough to represent a battlefield with three OPZONEs and six PARs for each of those OPZONEs. It also allows for a dispersion factor. Where six PARs per OPZONE may be adequate in most cases and the dispersion factor will allow for highly mobile forces, the MPM's maximum of three OPZONEs will fall far short of accurately representing a battlefield with the multiple areas of conflict expected on the future battlefield. The MPM is clearly not flexible enough to accurately represent the reality described above.

The MPM measures length of stay and evacuation delay in minimum increments of whole days. In the context described above, events on a highly mobile battlefield are increasingly time critical, including movement of troops and casualties. The MPM's measurement of time in whole days does not accurately represent that reality.

Under the MPM's increments of measure, a casualty who occupies a bed for any part of a day then occupies that bed for the entire day, regardless of the time of evacuation or return to duty. If a casualty who occupied a bed at 0700 was evacuated at 0800, according to the MPM, that bed will remain occupied until the next day. A casualty that is admitted to the same facility at 0900 could be placed in the bed vacated at 0800 but because the MPM considers that bed occupied, the MPM will regard this as an additional requirement. In this case, the MPM will overestimate the actual requirement simply because its minimum increment of measurement of one day does not accurately represent reality.

2. Compatibility.

Compatibility of the model is measured by two factors: compatibility with current planning factors and compatibility with current technology.

The same context used to evaluate the accuracy of the model will be used to evaluate the model's compatibility with current planning factors. As noted above, the MPM was not designed to support a highly dispersed and mobile force on a disjointed battlefield and is not flexible enough to be updated to match the current DPG. In addition to not matching the current DPG, the MPM uses outdated treatment protocols to determine average lengths of stay and average time required to stabilize patients prior to evacuation. The MPM is also not flexible enough to update its MDB with current treatment protocols.[16]

While the MPM does allow for user defined casualty rates, and therefore is compatible with the current joint casualty rates, it will not allow for the use of the more accurate individual service specific rates. The rate that is entered by the user is applied to all forces within that PAR regardless of their branch of service. There is only one case where the user defined rate is equal to the service specific rate, and this occurs when a single service constitutes the entire force employed in a specific OPLAN.

The MPM operates in the mainframe WWMCCS environment which has been replaced by the personal computer based GCCS. The MPM is not compatible with current GCCS technology and is not flexible enough to be updated short of being replaced.

3. Usability.

Usability is measured by three factors: the training required, user-friendliness, and speed.

The training required for MPM users is only three days. However, the complexity of the MPM model requires that the training be focused on understanding the language and syntax of the model commands vice the concepts and uses of the model. Without extensive training on the syntax of the model commands, the individual user, who is typically a medical planner, would find it nearly impossible to use the MPM for its designed objectives.

As the training required indicates, the MPM is not easy to use and mistakes are hard to correct. The MPM, in the online mode, requires the user to follow along a set series of menus, where the user defined input is entered and saved to tape or disc. The output cannot be displayed on the screen and the user must wait offline, until he receives the hard copy results, before the user defined inputs can be reviewed for errors. If errors are detected they may be corrected by modifying the MWF and resubmitting it for corrected sets of reports. This process would not appear to be user-friendly.

A great deal of "user-frustration" is also generated by the MPM's lack of speed. The entire process of inputting information online and then waiting offline for printouts is measured in days not hours. If corrections are required, then additional runs will be necessary to produce the desired outcome.

C. STRENGTHS AND WEAKNESSES.

As stated in the previous chapter, to evaluate a model is to determine if the model is an adequate substitute for reality to solve the problem or meet the objective. The model does not have to be perfect, just adequate enough to give the planner some confidence in the predictions that are derived from the model output. Every model has strengths and weaknesses, and in some cases the weaknesses are merely inconveniences that must be tolerated in order to use the model's strengths to solve a problem. For example, tolerating a nonuser-friendly model might be quite acceptable if the model is a highly accurate representation of reality.

This is not the case for the MPM. Although it is not user-friendly, it is also an inaccurate representation of reality. This is evident from a review of its strengths and weaknesses.

The MPM does have two strengths: 1) the reasonableness of the underlying mathematical algorithms which it uses to convert inputs and assumptions into outputs, and 2) the use of a dispersion factor allowing the planner to match the maneuverability of the medical support to that of the overall force. These are two very important factors in determining model accuracy and would allow the MPM to be used to represent reality, although with a very low confidence level.

The very low confidence in the output of the MPM is a matter of the weaknesses of the model. The MPM is not flexible enough to adequately represent reality and its increments of measurement are not precise, which together, significantly lower the overall accuracy. Additionally, the MPM is not compatible with current planning factors or current technology and is not flexible enough to be updated. Finally, the MPM has very low usability, which should not be tolerated given the relatively insignificant strengths of the model.

Overall, the MPM is outdated and inaccurate. The MPM's lack of flexibility prevents it from being updated and overcoming its weaknesses. However, the MPM's strengths are irreplaceable and should be incorporated into a replacement.

V. MEDICAL ANALYSIS TOOL

A. MEDICAL ANALYSIS TOOL.

The following evaluation of the MAT is based on review of users manuals and hands on use of the MAT operational prototype two.[17] As mentioned in chapter one, the MAT is still under civilian contract and is not fully developed. This has limited the amount and type of documentation and information that is available for review. Much of this evaluation is based on information that is a result of interviews conducted with CDR Mike Sashin, Joint Staff, J-4, Medical Readiness Division, who is the Action Officer responsible for the MAT's development and implementation.[18] Additional information was gathered during interviews with Mr. Raymond A. Haeme, a representative of Booz-Allen & Hamilton, the primary contractor developing the MAT.[19]

Only 'beta' versions of the MAT were available for hands on evaluation. Any conclusions as to the MAT's strengths, weaknesses, or capabilities are only valid for MAT operational prototype two, and may be subject to change once the MAT has been completed and released for use. For the purposes of this evaluation, any reference to "MAT", unless otherwise stated, is a reference to MAT prototype two.

The MAT is a requirements generator and a course-of-action analysis tool. The MAT is designed for requirements and capabilities analyses, planning, risk assessment, and decision support. After generating medical requirements to support an OPLAN, the medical planner can use the same data and scenario to perform course-of-action analysis and risk assessment. In the future, as part of a program called Medical Anchor Desk (MAD), the CINC Surgeon's staff will also be able to use the MAT in conjunction with other medical information systems to get real-time status of casualties and medical resources during actual operations. The MAT can be used as a stand-alone application or as part of the MAD. The MAD is a set of hardware and software that is connected to a network. The network enables communication among distributed planners in real time through both video-teleconferencing and application sharing.[20]

As a requirements generator, the MAT provides support for deliberate planning by qualifying the impact of a proposed OPLAN on the medical system. As a course-of-action analysis tool, the MAT provides medical planners the same capability to wargame the most effective use of forces that is currently available to operational planners in other communities. The MAT provides this capability by simulating the medical processes that would occur within a given network of medical resources for a specified scenario.

The MAT was built upon the functionality of the LPX-MED version 4.1. The LPX-MED was originally designed for the Modern Aids to Planning Program series of force on force simulations. The MAT operational prototype one (MAT OP1) was demonstrated during the 1995 Joint Warrior Interoperability Demonstration (JWID 95). At that time MAT OP1 was purely a course-of-action simulator/analyzer. The current version of the MAT was demonstrated during the JWID 96, as a component of an updated version of MAD. The MAT included all functions of its first prototype and added a medical requirements calculations capability based on the algorithms embedded within the MPM. The MAT improved on the MPM basic model and added a NATO medical support capability.

The models prior to the MAT were geared towards U.S. forces and medical treatment facilities. The current version of the MAT, however, incorporates data from Belgium, Denmark, Germany, Italy, and the United Kingdom specific to NATO medical services. The new medical support capability includes pre-defined NATO medical treatment facilities, evacuation assets, and casualty rates, NATO security classifications, and a NATO Detailed Deployment Plan (DDP) interpreter and processor.

The MAT is a Microsoft Windows compatible product that incorporates all the capabilities that exist in the Windows environment and makes them available to the MAT user. The MAT runs on a personal computer and imports data from GCCS to generate requirements and run simulations. All functions are run on the planner's computer including displaying output and printing reports.

Below is an evaluation of the MAT using the same criteria used to evaluate the MPM. Again, chapter three contains a discussion of these criteria. This evaluation is formatted in an identical manner as that presented in the previous chapter. This is done to facilitate a direct comparison of the two models. Following the evaluation is a summary of the MAT's strengths and weaknesses discovered in this evaluation.

B. EVALUATION OF THE MODEL.

1. Accuracy.

Again, accuracy will be measured by three factors: flexibility of the model, the degree of measurement of its inputs and assumptions, and the reasonableness of its mathematical relationships. The evaluation below discusses these factors, with the exception of the reasonableness of its mathematical relationships which was previously discussed in chapter III.

The process of measuring accuracy involves evaluating how well the model represents reality. In this case, the reality that the MAT attempts to model is the same as for the MPM, discussed in the previous chapter. Briefly, the future battlefield will be made up of multiple areas of conflict with the battles being waged by smaller, highly mobile, multi-disciplined, task organized units.[15] Again, this is the context for measuring accuracy.

The MAT is flexible enough to represent a battlefield with an unlimited number of OPZONEs and an unlimited number of PARs for each of those OPZONEs. The MAT also allows for a dispersion factor. With unlimited OPZONEs, unlimited PARs, and the dispersion factor, the MAT can accurately represent any battlefield with the multiple areas of conflict expected on the future battlefield. The MAT is clearly flexible enough to accurately represent the reality described above.

The MPM measures length of stay and evacuation delay in minimum increments of minutes. In the context described above, events on a highly mobile battlefield are increasingly time critical, including movement of troops and casualties. The MPM's measurement of time in minutes is a very accurate representation of that reality.

2. Compatibility.

Again, compatibility of the model is measured by two factors: compatibility with current planning factors and compatibility with current technology.

The same context used to evaluate the accuracy of the model will be used to evaluate the model's compatibility with current planning factors. As noted above, the MAT was designed to support a highly dispersed and mobile force on a disjointed battlefield. The MAT was designed to incorporate the current DPG and is flexible enough to accommodate any changes to the DPG in the future.

In addition to being compatible with the current DPG, the MAT uses the most updated treatment protocols available to determine average lengths of stay and average time required to stabilize patients prior to evacuation. The MAT is also flexible enough to modify its current treatment protocols as updates become available.

The MAT allows for user defined force casualty rates for NATO operations and U.S. joint operations, as well as service specific casualty rates for both. The MAT is clearly compatible with current planning factors and is also flexible enough to incorporate any modifications in the future.

The MAT operates in a personal computer environment and is compatible with GCCS. The MAT incorporates a TPFDD and map importing capability as well as a NATO DPP processor as discussed earlier in this chapter.

3. Usability.

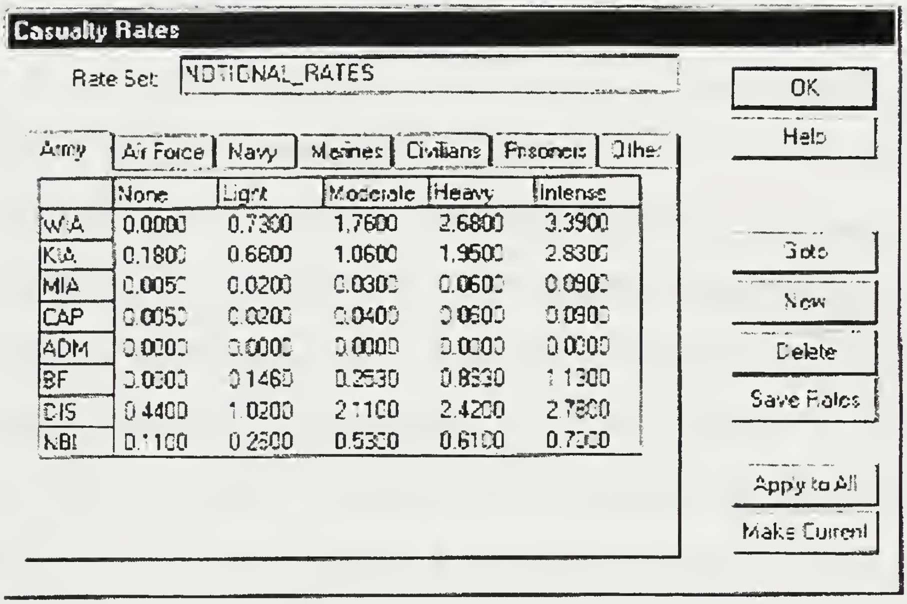
Usability is measured by three factors: the training required, user-friendliness, and speed.

The training required for MAT users is five days and is incorporated into GCCS training. The emphasis of the training on the MAT is on the concepts and uses of the model to become better planners, not better computer operators.

As the training required suggests, the MAT is very easy to use and mistakes are easy to correct. As stated earlier, the MAT is a Microsoft Windows compatible product incorporating all the capabilities that exist in the Windows environment and making them available to the MAT user. Using the MAT is as simple as pointing and clicking a mouse. Figure 6 is a sample of MAT dialogue boxes which illustrate how user-friendly the Windows environment is for the ultimate user.

A great deal of usability is generated by the MAT's much improved speed. In comparison to the MPM, the entire process of inputting information, correcting errors if necessary, and generating reports is a matter of minutes rather than days. MAT's output can be viewed on screen as the planner works and all graphs and charts are instantly updated as corrections or changes are made.

Casualty Rate Dialog Box



: Casualty Source Dialog Box, Requirements Tab

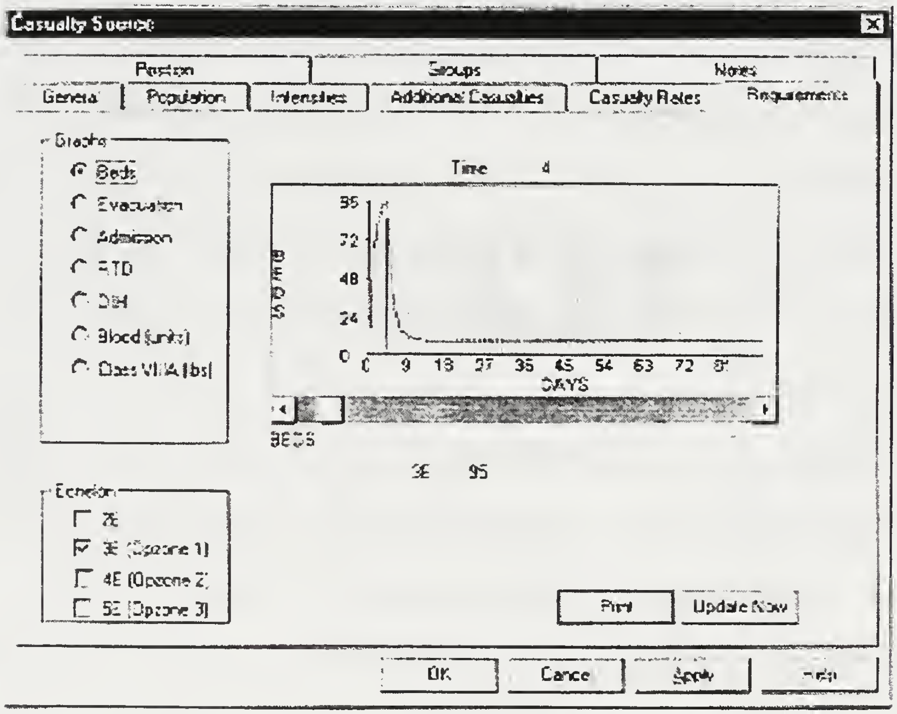


Figure 6.

C. STRENGTHS AND WEAKNESSES.

As stated in the previous chapter, to evaluate a model is to determine if the model is an adequate substitute for reality to solve the problem or meet the objective. Again, the model does not have to be perfect, just adequate enough to give the planner some confidence in the predictions that are derived from the model output. Every model has strengths and weaknesses, and in some cases the weaknesses are merely inconveniences that must be tolerated in order to use the model's strengths to solve a problem.

In the case of the MAT, its strengths far outweigh its weaknesses. The weaknesses that do exist are minimal and can be easily avoided.

The MAT has one weakness worth noting. Optimal operation of the MAT requires significant amounts of computer memory. MAT scenarios use memory to create scenario lengths, casualty sources, and medical facilities. The most memory-consuming variable is scenario length. Increasing the scenario length not only uses more memory but will cause the model to run much slower. Users of Windows 3.1x may have difficulty reading in large scenario files (files over 60 days with more than ten casualty sources). Some ways to avoid memory constraints are to use a computer with as much RAM and available hard drive space as possible, use Windows 95 or Windows NT which handle the memory problems better than Windows 3.1x, and free up as much hard drive space as you can by deleting unnecessary files.

The weakness noted above is a minor inconvenience when compared to the strengths of the MAT, which are numerous. The MAT's strengths are that it is highly accurate, compatible with current planning factors, compatible with current technology, and very usable.

Overall, the most noteworthy strength of the MAT is that it is so flexible that as changes occur in planning factors and technology the MAT can change with them. The MAT incorporated the strengths of the MPM in a much more accurate, compatible, and usable model than the MPM.

VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE STUDY

A. SUMMARY.

The readiness mission of the MHSS encompasses the ability to mobilize and sustain field medical services and support for any operation requiring military services and to project and maintain the continuum of health care resources required to provide for the health of the force during a time of war or lessor conflict. The concept of medical readiness is to plan and program for the requirements of, and be ready to execute, the wartime mission.

The DPG serves as the basis for all planning and programming activities within the DoD. The DPG establishes the potential combat operations by issuing 'scenarios' which form the analytical basis for determining planning and programming requirements. These scenarios are used to generate the critical planning factors, i.e., casualty estimates and evacuation streams, which lead to determination of wartime requirements within the context of echelons of care and OPZONEs.

Casualty estimates constitute the expected workload that a network of medical assets must be prepared to deal with for a given scenario. The casualty streams constitute the assumptions of how a network of medical assets intends to handle the workload it faces in a given scenario. Models are used to translate the workload and assumptions for a given scenario into a requirement for that scenario. Such models are designed to take the inputs--workload and assumptions--and produce an output--the requirement.

The process of modeling entails using qualitative and/or quantitative information, within a framework representing reality, to predict the outputs or outcomes of a certain course of action within that reality. A model, then, is a substitute for reality when that reality is too dangerous, too expensive, or just not possible. To evaluate a model is to determine if the model is an adequate substitute for reality to solve the problem or meet the objective.

Since the mid 1980s, the current model, the MPM, has been the subject of continuous criticism from agencies both inside and outside the DoD. The MPM's validity has been questioned and a call for updating or replacement has been made. The Dod's response to this call is the MAT. The purpose of this thesis was to conduct an evaluation to determine if the proposed replacement to the MPM was any more valid than the MPM itself. This entailed evaluating both the MPM and the MAT.

The most important part of any evaluation is setting the criteria against which the models will be evaluated.

Accuracy, compatibility, and usability are the criteria that were used in this thesis to evaluate the MPM and the MAT models. The criteria are made up of numerous factors which are either direct measurements or proxies used to measure the validity and relevance of each model. The model does not have to be perfect, just adequate enough to give the planner some confidence in the predictions that are derived from the model output. Every model has strengths and weaknesses, and in some cases the weaknesses are merely inconveniences that must be tolerated in order to use the model's strengths to solve a problem.

B. CONCLUSIONS.

The MPM has two strengths: 1) the reasonableness of the underlying mathematical algorithms which it uses to convert inputs and assumptions into outputs, and 2) the use of a dispersion factor allowing the planner to match the maneuverability of the medical support to that of the overall force. These are two very important factors in determining model accuracy and would allow the MPM to be used to represent reality, although with a substantial lack of confidence in the output.

The lack of confidence in the output of the MPM is a result of the weaknesses of the model. The MPM is not flexible enough to adequately represent reality and its increments of measurement are not precise, which together, significantly lower the overall accuracy. Additionally, the MPM is not compatible with current planning factors or current technology and is not flexible enough to be updated. Finally, the MPM has very low usability, which should not be tolerated given the relatively negligible strengths of the model.

Overall, the MPM is outdated and inaccurate. The MPM's lack of flexibility prevents it from being updated and overcoming its weaknesses. However, the MPM's strengths are irreplaceable and should be incorporated into a replacement.

By contrast, the strengths of the MAT far outweigh its weaknesses. The weaknesses that do exist are minimal and can be easily avoided. The MAT's strengths are that it is highly accurate, compatible with current planning factors, compatible with current technology, and very usable. The most noteworthy strength of the MAT is that it is sufficiently flexible that as changes occur in planning factors and technology, the MAT can change with them.

The MAT has one weakness worth noting. Optimal operation of the MAT requires significant amounts of computer memory. This weakness is a minor inconvenience when compared to the strengths of the MAT, which are numerous.

The MAT incorporated the strengths of the MPM in a much more accurate, compatible, and usable model than the MPM. Based on the criteria set in chapter III, and the evaluations of the models in chapters IV and V, the conclusion is that the MAT is a much more appropriate model than the MPM and should replace it.

The implications of the MAT replacing the MPM are that the DoD will be able to utilize a much more accurate model in the process of generating medical wartime requirements and therefore be able to determine a much more accurate prediction of wartime requirements to support planning. It should be noted that the MPM's lack of accuracy tended to produce overestimations rather than underestimations of wartime requirements. The lower estimates of requirements generated by more accurate models should not be mistaken for a manipulation of the model to downsize the MHSS.[18]

However, if downsizing of the MHSS is inevitable, using the more accurate MAT to determine wartime requirements as a basis for planning a smaller force would yield a much more appropriate force, for the given DPG, than would the less accurate MPM. The issue of how significantly the MHSS wartime requirements have actually declined has sparked considerable disagreement.[21] The DoD's policy is to maintain as small an active peacetime force as national security, military strategy, and overseas commitments permit.[22] This objective underlines the need for the most accurate model possible. At this time that model is the MAT, which is due to be released by June of 1997.

C. RECOMMENDATIONS FOR FUTURE STUDY.

The process of conducting the research for this thesis has led to recommendations for future study in two areas. Both areas have such significant impact on the MHSS's requirements generation process that future study in these areas will greatly enhance development of that process.

The first recommendation for future study is in the area of casualty rate estimation. The casualty rate estimate is the most significant factor in determining the expected workload for a given scenario. Minute changes in the casualty estimate will yield large changes in predicted requirements. Current casualty rate estimates are based on historical data collected from previous conflicts. There is some confusion as to which rates to use in planning.[23] This is not necessarily a question of inaccurate rates, but rather the mis-application of these rates in the absence of clear guidance and understanding of rate behavior. Published rates are neither right nor wrong, just applied reasonably or unreasonably.[24] Because of its significant impact on requirements generation, this area warrants future study.

The second recommendation for future study is in the area of cost versus benefit analysis of the trade off between evacuation assets or medical assets in theater. This is to say that there is a trade off between evacuation assets and medical assets (see Figures three and four in chapter II). More medical assets in theater means that casualties can be treated in theater instead of evacuated rearward, decreasing the requirements for evacuation assets. This trade off also works in reverse. There exists an as yet unknown rate of substitution between medical assets and evacuation assets that could be used to optimize, based on cost, the level of both. The impacts on MHSS force structure and the potential for saving money in an ever decreasing budget are significant enough to warrant future study in this area.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

CONUS	Continental United States
DNBI	Disease, Non-Battle Injury
DoD	Department of Defense
DPG	Defense Planning Guidance
GAO	Government Accounting Office
GCCS	Global Command and Control System
JOPES	Joint Operation Planning and Execution System
JWID	Joint Warrior Interoperability Demonstration
KIA	Killed in Action
LPX-MED	Logistics Processor External-Medical
NATO DDP	North Atlantic Treaty Organization Detailed Deployment Plan
MAD	Medical Anchor Desk
MAT	Medical Analysis Tool
MDB	Medical Database
MHSS	Military Health Services System
MIA	Missing in Action
MPF	Medical Planning Factors
MPM	Medical Planning Module
MTF	Medical Treatment Facility
MWF	Medical Working File
OPLAN	Operation Plan
OPZONE	Operation Zone
PAR	Population at Risk
POW	Prisoner of War
RAM	Random Access Memory
RTD	Return to Duty
TPFDD	Time Phased Force Deployment Data
WWMCCS	World Wide Military Command and Control System

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